Forestry Research West

Forest Service
U.S. Department of Agriculture

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A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

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Forest Service scientists have been studying the effects of chemical insecticides on the forest environment. Branch samples were taken both before and after the application of insecticides to determine their impact on forest insects. Read more about it on the facing page.

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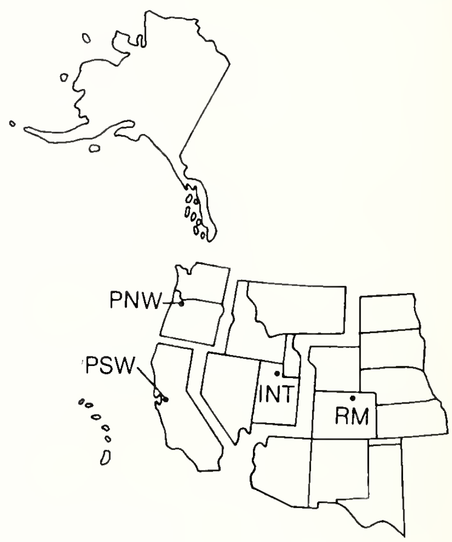


Searching for safe insecticides

What happens when a chemical insecticide is introduced into the forest environment to attack a destructive insect? What is the impact on other insects, birds, and animals? The myriad variables involved in the life sciences make the search for answers to these seemingly simple questions far more complex than is apparent.

Yet, the answers must be found before the Environmental Protection Agency will approve and register an insecticide for use in controlling a forest pest. The agency must be given sufficient data to demonstrate not only the effectiveness of the chemical on the target insect but also that its use will not present intolerable hazards to man and the environment.

The recently concluded Douglas-fir Tussock Moth Program gave Forest Service researchers and their cooperators a chance to seek these answers in some of the most comprehensive safety tests of chemical sprays ever attempted in a forest environment.

The USDA Expanded Douglas-fir Tussock Moth Research and Development Program began in late 1974. Although the Douglas-fir tussock moth was the target organism, woven throughout the program was a continuing thread of concern for other forest life . . . insect-eating birds, fish and other aquatic life, pollinating insects, and insect predators that might prey on the tussock moth or other forest pests.

The safety of these non-target organisms had to be established "within tolerable levels" before the candidate insecticides—carbaryl (Sevin-4-Oil), acephate (Orthene), and diflubenzuron (Dimilin) could be considered for registration by the EPA for forest use.

The environmental safety tests were conducted under the coordination of Patrick J. Shea, research entomologist at the Pacific Southwest Forest and Range Experiment Station, Davis, California. Investigators from the PSW Station, the U.S. Fish and Wildlife Service, Central Washington State College, Washington State University, the University of Idaho, and Brigham Young University collaborated in the intensive field work and laboratory analyses.

Three candidate chemicals were sprayed on test plots in the Wallowa-Whitman National Forest in eastern Oregon.

Screening

Before any chemicals are considered by the Forest Service for use in the field, they are carefully screened in the laboratory to determine not only their effectiveness against the target insect but also to eliminate as soon as possible, chemicals that they find have potential for irreversible environmental damage.

Each insecticide formulation is tested literally thousands of times. The chemicals are applied to laboratory-raised insects in precisely calibrated amounts to determine the minimum quantity needed to kill the insects at any life stage. By extrapolation, the calibrated lethal doses are converted to minimum applications—ounces or pounds per acre—that will be effective in the field.

As they calibrate lethal concentrations, the scientists check the effects of the candidate insecticides on other organisms. They explore toxicity to humans, wildlife, beneficial insects, and other aspects of the forest ecosystem.

The safety tests included analyses of the effect of insecticides on brain activity in birds and fish.

No matter how numerous or meticulous they are, laboratory tests are not enough. Extensive laboratory data were available on acephate, carbaryl, and diflubenzuron, particularly on their toxicity. But there was little information on their effect on non-target organisms in western forests.

The complete data EPA would need to approve registration and establish criteria for use could only be obtained through extensive experiments and safety tests in the field.

Field experiments

Covering more than 2,800 ares of land in the Wallowa-Whitman National Forest in the Blue Mountains of eastern Oregon, and spanning a 3-year period, the environmental safety tests were among the largest and most comprehensive ever planned and conducted for the specific purpose of determining the impact of insecticides on non-target forest organisms.

Tests of this kind were vitally needed because, in the past, safety tests have been conducted as a somewhat secondary objective in concert with experimental control programs. It is almost impossible to get the results needed under these conditions. To be successful, the safety tests must be the prime objective, and they must be numerous enough and large enough to be representative of operational treatments. Also, there must be ample time to gain precise familiarity with the range, movements, and other characteristics of the non-target life forms concerned.

With these factors in mind, the safety tests were deliberately planned to exclude any concern for heavy kill of the tussock moth or even the presence of large populations of the insect. The tests were set up with two key objectives: 1) to determine the effect of the three insecticides on selected residents of the forest ecosystem, and 2) to obtain enough field evaluation data on the chemicals so that the safety of their handling, use, and effect on the environment could be demonstrated for possible EPA registration.

Test plots

Test plots of 360 acres each were laid out in the basic study area in the summer of 1975. Although the forest land was typical of tussock moth habitat, there were no detectable moth populations at the time the test plots were selected and laid out. Six plots were scheduled for chemical treatment, and three were held as controls that would not be sprayed.

Each of the plots included a mountain stream so that aquatic life and water quality could be checked and monitored. The central 20 acres of each plot was staked out in a grid pattern so that observations of birds could be oriented and mapped. Similar but smaller grids were laid out for studies on small mammals.

Terrestrial insects, aquatic insects, birds, small mammals, and fish were selected as representative of naturally occurring populations of the forest ecosystem. Species within these five life forms were selected for susceptibility, beneficial values, and linking positions within the food chain.

In addition, an extensive residue analysis study was made to determine how long the chemicals remained active in trees, vegetation, soils, and water.

Pre- and post-spray

Although the tests spanned 3 years, the basic time frames that controlled sequential events were the "pre-spray" and "post-spray" activities. Some pre-spray activities took place months in advance of aerial application of chemicals, some on the day that spraying took place. Scheduling for post-spray activities again involved time-spans ranging from minutes to months after the sprays were completed.

Immediately after the test plots were established in 1975, the research teams concerned with each life form began surveying resident populations, studying range and movement, and collecting specimens for use in comparison with post-spray populations.

Aquatic sampling stations were set up in each stream to determine normal populations, identify species involved, and learn their drift patterns. Just before spraying, sampling was stepped up to half-hour and hourly intervals. Similar schedules were followed on the day of the spray and several days thereafter. Sampling was conducted from the summer of 1975 through the 1977 season.

Malaise traps—cone-shaped traps of plastic or canvas—and drop cloths were strategically placed throughout the plots to capture terrestrial insects. The traps were generally operated and checked in sets of three throughout the 3-year period.

Studies on rainbow trout and small mammals, primarily rodents such as deer mice and meadow voles, were started in 1976. Rodent trails and habitat were mapped. Mice and voles were trapped, weighed, and checked for health. Some were freed, others were killed and preserved as specimens for later bioanalysis.

To check fish survival, live-boxes containing fingerlings of rainbow trout were placed in down-stream locations. The fingerlings were observed as they fed on aquatic life that passed through the live-box mesh. Boxes were checked every hour on the day of the spraying and for several days thereafter. Streams were also checked daily to record impact on native fish.

In June 1976, the chemicals were sprayed on selected test plots from helicopters flying 50 feet above the treetops. Pilots followed color-coded panels and flags so that chemicals could be laid down in 100-foot swaths.

Researchers designed and built a new and improved trap for sampling populations of aquatic insects.

All spray formulations contained a bright pink dye so the mist could be traced. The carbaryl was applied at the rate of 2 pounds of active ingredient per gallon of fuel oil per acre. Acephate was applied on some plots at 1 pound active ingredient per gallon of water per acre. Diflubenzuron was applied at either 2 or 4 ounces per gallon of water per acre.

Almost as soon as the mists settled in the tree foliage, the research teams were back at their stations to collect post-spray samples. Specimens collected then and on succeeding days, months, and years were taken to cooperating laboratories for comparison with specimens collected in the pre-spray periods.

Laboratory analyses

The laboratory tests ranged from relatively simple population censuses and visual observation of health and vigor to histochemical or biochemical autopsies to determine effects of chemicals on brain activity.

Literally tens of thousands of specimens were collected in both the aquatic and terrestrial insect surveys. For aquatic insects, the concern was with population groups, rather than individual species. If there was a discernible shift in population groups, was it a natural occurrence or caused by the chemicals? The seasonality and dynamics of insects are fairly well known and these variables could be ascertained, but the big question was what really caused year-to-year shifts, if such occurred.

These complexities—the enormous task of processing thousands of specimens, the taxonomic diversity, the profiles of seasonal abundance, and the need for meaningful comparisons of treatments over seasons—also existed in the analyses of terrestrial insects. But they were compounded by additional concern for analyses of insect activity in relation to forest vegetation.

For example, were patterns of foraging on pollen and nectar plants changed? Was pollen contaminated by sprayed insects? Did fruit or blossom production change? Did a drop in predator population alter the balance in the insect ecosystem?

The search for answers was further complicated by changes in weather, simple unknowns, or "natural accidents." For example, cattle broke into one research plot. The researchers were then faced with the question as to whether or not a dramatic upsurge in an insect population group was caused because the insects were attracted to cattle droppings.

The researchers also monitored the birds, mammals, and fish. Was there a change in post-spray residents? Was species behavior changed? Histochemical and biochemical analyses were made to determine possible change in brain activity, as measured by cholinesterase (ChE)—the substance that triggers transmission of nerve impulses.

A thorough assessment was also made of the chemical residues remaining in the forest area itself. Analyses were made to determine the initial levels of contamination and to learn how long the chemicals persisted in detectable amounts. More than 600 samples of soil, water, and vegetation were analyzed by high-pressure liquid chromatography or by gas chromatography. The residuals were calculated in parts per million. Depending on the sample and the chemical, persistence ranged from 1 to 63 days.

Assessments of this sort are extremely rare, and there are little or no data available on the residuals in the forest environment after chemical application. These surveys and the analyses will provide benchmark techniques for future research.

Materials registered

What did the 3 years of field work and thousands of tests and analyses produce? In large part, the safety tests produced data that resulted in the EPA registering Sevin-4-Oil (2-quart concentrate diluted up to 1:1 with fuel oil per acre) for use as control of the Douglas-fir tussock moth, and the registration of Orthene for use against the western spruce budworm (½ pound active ingredient per gallon of water per acre). The data on environmental safety that EPA used to certify Orthene for use on the budworm were collected in the DFTM safety tests and supplemented by additional tests on the spruce budworm in Idaho in 1977.

The EPA is currently reviewing the safety data on Orthene for registration for use in control of the tussock moth. Data in Dimilin have also been submitted to EPA for review.

The spray formulation—the combination of the chemical insecticide and its "carrier" (such as fuel oil or water)—was checked and rechecked before takeoff.

The chemicals did have some impact on the non-target organisms. Sevin-4-Oil had severe short-term effects on flying insects and ants, but populations appeared to recover within a reasonable period. It also produced severe long-term effects on bees and aquatic insects. EPA criteria for use call for precautions during pollination seasons or periods when bees are present, and the principal investigators have recommended that Sevin-4-Oil not be used where it could contaminate lakes and streams.

Dimilin had both immediate and long-term effects on yellowjackets, but in general it appeared to be one of the most environmentally safe of the chemicals tested.

The principal investigators have also recommended additional research to explore in greater depth the effect of brain depression in birds and fish. Both Sevin-4-Oil and Orthene depressed ChE activity.

In addition to the registration and potential registration of control chemicals, the procedures used to obtain the data necessary for registration—both efficacy and safety tests—have been adapted by the Forest Service as standards for testing insecticide materials in the western United States.

Finally, the scope of the environmental safety tests and the tremendous amount of data collected have value far beyond decisions on the future use of these particular chemicals. The tests have, in fact, produced an invaluable data bank that will continue to provide for years to come both questions and answers relating to problems that may be yet unknown.

—by John K. McDonald
Pacific Southwest Station

Mention of a pesticide does not constitute a recommendation for use by the USDA, nor does it imply registration under Federal Insecticide, Fungicide and Rodenticide Act as amended. Mention of a proprietary product does not constitute an endorsement by the USDA.

Managing spruce-fir forests for multiple uses

The spruce-fir type of Wyoming, Colorado, and northern New Mexico is the largest and most valuable forest ecosystem in the central Rockies. This type is prized for sawtimber, habitat for wildlife, forage for livestock, recreational opportunities, scenic beauty, and high water-yielding areas.

Spruce-fir forests grow on a wide range of sites with great diversity of stand conditions and characteristics. This diversity complicates the development of silvicultural systems needed to convert old-growth to managed stands for a variety of uses. Therefore, land managers aiming for multiple use goals must base decisions on silvical characteristics, resource and protection requirements, social and economic considerations, and other factors.

Scientists at the Fraser Experimental Forest are studying different cutting patterns and how they affect forest resources.

Scientists with the Rocky Mountain Station's "Multiresource Management for Subalpine Forests" research unit at Fort Collins, Colorado are working to find ways to better manage spruce-fir forests for a number of resource uses.

Much of their research takes place on the Fraser Experimental Forest, a 36-square-mile outdoor laboratory, 50 miles west of Denver. There, efforts focus on the study of timber, water, and wildlife management in the subalpine ecosystem.

A major portion of the research program at Fraser is concerned with the effect of harvesting systems on forest regeneration, growth and yield, water quality and quantity, and wildlife habitat.

Englemann spruce is the most important commercial species in subalpine forests of the central Rockies. Natural regeneration of the species in the open has been a major management problem, partly because of the adverse impact of high solar radiation on young seedlings. Spruce reproduces best in shade, and many old-growth forests have an understory of advanced reproduction with a fair amount of spruce. Studies show that if these are carefully logged, the stands can be perpetuated. Other findings show that on shaded mineral soil, clearcut openings 400 to 500 feet wide are likely to restock naturally on north slopes, but few seedlings will survive on south slopes unless openings are kept below 200 feet in diameter.

Scientists have also been experimenting with different harvesting methods. Robert Alexander, project leader and chief silviculturist says, "Studies indicate that maximum potential spruce timber yields can be realized under either even- or uneven-aged silvicultural systems. However, economics plays an important role. One of the most important factors affecting the cost of selling timber is the number of entries needed for harvesting. Clear cutting and simulated shelterwood, where the overstory is removed from an established stand of advanced reproduction, require only one entry. In addition, costs of sale layout, marking, and sale contract administration are lower for clear cutting; it is the most economical method in terms of volume removed per acre and unit of road built; and it permits the greatest flexibility in selection of logging equipment, with minimum concern for protection of residual trees."

Water

In the West, water is vital to life and economic development. Not only are spruce-fir forests the most productive timber resource, but they occur on the most productive water yielding areas, with 90 to 95 percent of natural streamflow coming from snowmelt.

As early as 1955, tests of different timber cutting patterns were begun at Fraser. Scientists wanted to know what effect the cutting had on snow accumulation, melt, and runoff.

Although these studies are continuing, important findings show that water production can be increased by clear cutting. The size and arrangement of the pattern is critical, however. The largest water increases occur when 30 to 40 percent of a drainage is harvested in small clear-cut patches of 3 to 5 acres, dispersed over the entire watershed.

Alexander explains, "with this pattern, more snow accumulates in the openings than under adjacent stands. While total snowfall in the drainage is not increased, the rate of melt is.

"Cutting openings larger than 10 or 15 acres may actually decrease water available for streamflow. The wind then scours and blows snow out of the openings into adjacent stands where fall recharge requirements, evaporation, and evapotranspiration are greater. At the same time, the airborne snow is subject to greater sublimation losses."

Although the choice of cutting method depends on management objectives, and on resource, social, and economic values, irregular patches appear more pleasing aesthetically than geometric ones, and they are as effective in accumulating snow.

Wildlife

Both game and non-game wildlife have played a major role in research at Fraser. Spruce-fir forests are summer habitat for big game animals such as mule deer and elk.

Researchers with the multiresource management project have found that big game use of these forests can be improved by certain timber cutting practices such as clear cutting and group selection.

Between 1954 and 1956, the Fool Creek Watershed on the Fraser forest was logged in alternating clearcut and uncut strips. Initially, deer preferred the uncut strips.

Solar radiation can cut the survival rate of spruce seedlings. Here, scientists check young seedlings under a shaded area.

Twelve years after logging, use of the cut strips was 3 times that of uncut areas. Use of the whole watershed was double that for an adjacent control watershed. The reason . . . cutting increased forage production. By 1972, understory herbage on cut strips exceeded that on uncut strips by approximately 463 pounds per acre, with no apparent differences in nutritional quality.

Little research has been done on non-game animals in relation to cutting methods in the spruce-fir type. However, Alexander says that cutting methods that create small, dispersed openings provide a range of habitats attractive to birds and small animals.

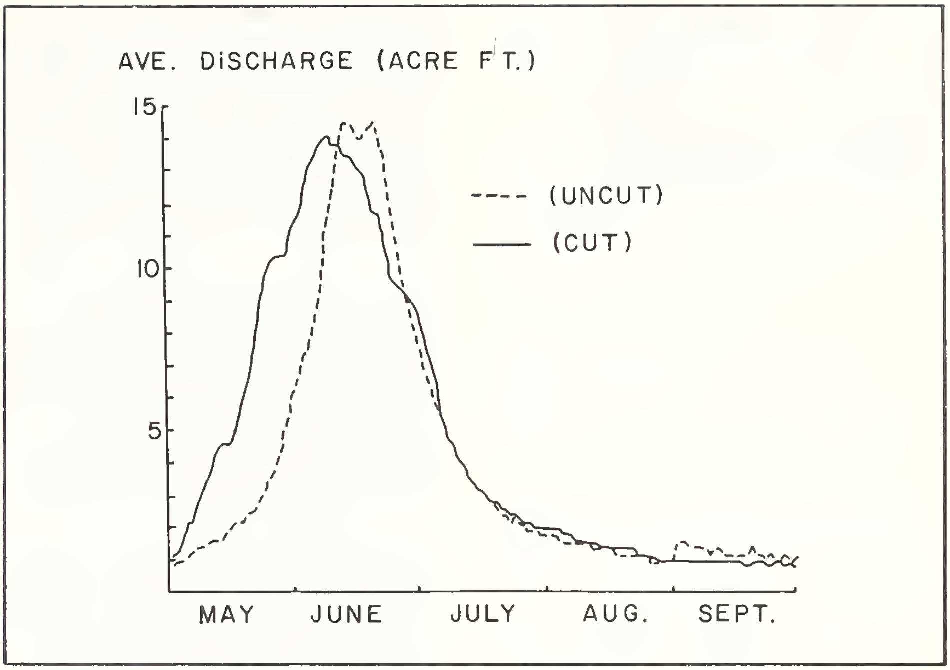
In a cooperative study, scientists from the U.S. Fish and Wildlife Service are determining the response of non-game birds and small mammals to timber harvesting. Initial results have already described site characteristics important to cavity-nesting birds.

These and similar studies assisted in developing the 1977 Forest Service policy to provide habitat needed to maintain viable, self-sustaining populations of cavity-nesting and snag-dependent wildlife species on National Forests.

Conclusions

If one general management implication could be drawn for subalpine forests that would meet most management goals it would lean toward cutting small openings or patch cutting. This method provides maximum yields of timber at minimum costs, promotes the largest increases in water production without undue reduction in quality, and produces diversity in food supply and cover for many wildlife species.

Although scientists at the Rocky Mountain Station have come a long way in developing knowledge on the silvics, silviculture, and management of trees in the subalpine ecosystem, work is continuing at Fraser and other areas to further knowledge about the processes and interrelationships among resources and management practices.



Certain timber cutting patterns can increase water runoff. This diagram compares discharge from an uncut area to that of a cut area.

The recent publications listed below detail research results and observations by scientists at the Fraser Experimental Forest and other subalpine forest areas. They are available from the Rocky Mountain Station.

Additional information can be obtained by contacting Robert R. Alexander, Rocky Mountain Forest and Range Experiment Station, 240 West Prospect St., Fort Collins, Colorado 80526, (303)221-4390, FTS-323-1249.

Cutting methods in Relation to Resource Use in Central Rocky Mountain Spruce-Fir Forests, by Robert R. Alexander. Reprinted from the Journal of Forestry, Vol. 75, No. 7.

Environmental Factors Affecting Natural Regeneration of Engelmann Spruce in the Central Rocky Mountains, by Daniel L. Noble and Robert R. Alexander. Reprinted from Forest Science, Vol. 23, No. 4.

The Fraser Experimental Forest, Colorado, by Robert R. Alexander and Ross K. Watkins. General Technical Report RM-40-FR18.

Dead Trees Used by Cavity-Nesting Birds on the Fraser Experimental Forest; A Case History, by Virgil E. Scott, Jill A. Whelan, and Robert R. Alexander. Research Note RM-360-FR18.

Duration of Deer Forage Benefits After Clearcut Logging of Subalpine Forest in Colorado, by Wayne L. Regelin and Olof C. Wallmo. Research Note RM-356-FR18.

The Fraser Experimental Forest, Colorado, Research Published 1940-1977, compiled by Robert R. Alexander. General Technical Report RM-40A-FR18.

—by Rick Fletcher
Rocky Mountain Station

How much fuel — How will it burn

Fire danger was high as thunderheads rolled over the Bitterroot National Forest August 4, 1961. The vast stands of Douglas-fir and lodgepole pine were tinder dry. A tangled mass of beetle-killed and windthrown trees, half-hidden by shrubs and other vegetation, lay beneath the overstory.

Lightning struck, and one of the worst forest fires in Montana's history—the Sleeping Child—was off and running. By the time it was controlled 6 days later, more than 28,000 acres of timber and vegetation had been reduced to blackened stems and ashes.

Land managers and scientists have a common observation about the Sleeping Child fire—"Fuels had built up." A heavy accumulation of downed material—the result of a mountain pine beetle epidemic—created a potentially dangerous fire situation.

Fuel buildup is one of the problems specifically addressed in the revised fire policy announced in 1978. "Fire management will be treated in land management plans as a cost-effective way . . . to improve wildlife habitat, remove brush and small trees to improve timber stands, help prevent the spread of forest insects and diseases, and reduce the threat of large fires by preventing accumulation of dry forest debris."

Scientist samples and measures dead-down woody materials by diameters and number of intercepts to establish fuel loading relationships.

The new concepts and programs inherent in the revised policy offer a major challenge to land managers. In the total systems approach to fire, fuels management—managing potential fire intensity—is of paramount importance.

An Intermountain Station research work unit at the Northern Forest Fire Laboratory is conducting studies to develop the know-how that will enable land managers to manage fuels intelligently. Led by Project Leader Hal Anderson, the Fuel Science unit has developed methods for evaluating fuels and potential fire behavior.

Fuel appraisal

The fuel science researchers say the key to fuel appraisal is describing fuel in terms of potential fire behavior. Fire managers interpret these descriptions by mathematical modeling or experienced judgment.

Mathematical modeling, the basis for the National Fire Danger Rating System, offers excellent possibilities for fuel appraisal. Experience is important, too—a veteran fire officer can integrate and appraise many factors that are difficult to quantify.

What is acceptable?

A question that is continually pondered and asked by land managers is, "What tonnages of fuel are acceptable?"

Both man's activities and natural vegetation development lead to widely varying fuels and hazard potential. Residues of thinning and logging can range from 5 tons to more than 200 tons per acre. Associated fire potentials range from easily controlled intensities of 20 Btu's per second foot (Btu/s-ft) to holocausts of 20,000 Btu/s-ft or more.

To decide how much fuel is acceptable requires that one mentally integrate the many factors bearing on the decision. According to Anderson, this can be done in a logical manner.

First, consider the land management objectives and values at risk. Next, appraise fuels by (a) acquiring a description of the fuels and (b) interpreting fire potential. Finally, consider other factors such as fuel and fire potential on adjoining areas, suppression capability, fire history, and fire's biological role.

Anderson says a lot of time and effort can be spent acquiring descriptions of fuel and predicting fire behavior. Before embarking on these efforts, be as certain as possible that the fuel data will facilitate planning or decision making. To integrate fuel appraisals into planning activities, the following process is suggested:

1. Analyze the planning situation to identify the problem or decision to be made. Decide what fire behavior information is required for the decision and to what accuracy.

2. Acquire the needed information. Use quantitative information whenever possible. Substitute experienced judgment if necessary.

3. Interpret the fuel appraisal in terms that help answer land management questions.

Other uses

Fuel information from inventory and prediction is not restricted to appraising fire potential. The information has other applications, including:

1) Familiarize people with how different fuel tonnages look.

2) Improve communication and understanding of fuel and debris problems.

3) Administer contracts for debris disposal.

4) Describe utilization potential.

5) Locate sale areas where downed fuels are heaviest so that cleanup will do the most good.

6) Locate precommercial thinning areas to minimize downed fuels.

Application

The fuel description methods developed by the Fuel Science group at the Northern Forest Fire Laboratory are in use by other research units, both within the Intermountain Station and at the Rocky Mountain Station. All of the Forest Service western Regions use some forms of the methods, some exclusively. Other Federal agencies and western States are applying the inventory and appraisal techniques. Some private companies, such as Weyerhaeuser and Great Northern Paper, are also using inventory and prediction methods to evaluate fiber potentials.

If you would like "how-to" information on fuel science research, write for one of the following publications:

Handbook for Inventorying Downed Woody Material, by James K. Brown, INT-GTR-16-FR18.

Users' Guide to Debris Prediction and Hazard Appraisal, by John V. Puckett, Cameron Johnston, Frank A. Albini, James K. Brown, David L. Bunnell, William C. Fischer, and J. A. Kendall Snell.

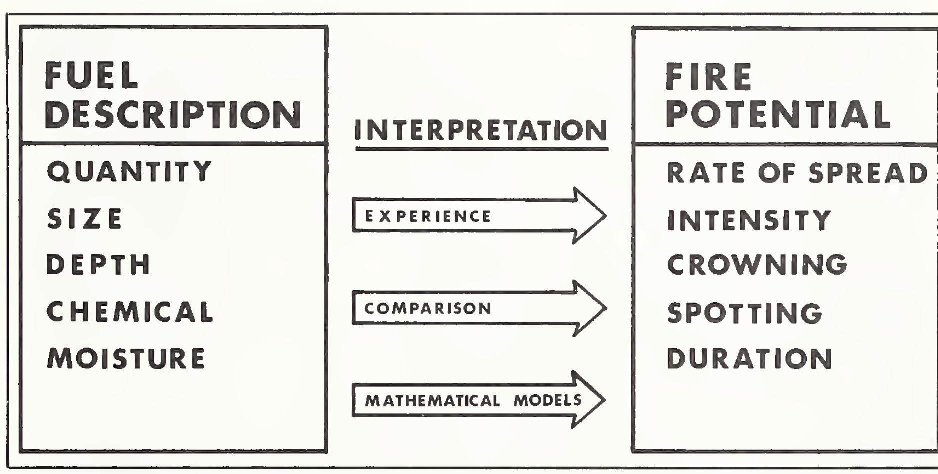
Handbook for Predicting Slash Weight of Western Conifers, by James K. Brown, J. A. Kendall Snell, and David L. Bunnell, INT-GTR-37-FR18.

Graphic Aids for Field Calculation of Dead, Down Forest Fuels, by Hal E. Anderson, INT-GTR-45-FR18.

Weight and Density of Crowns of Rocky Mountain Conifers, by James K. Brown, INT-RP-197-FR18.

Predicting Slash Depth for Fire Modeling, by Frank A. Albini and James K. Brown, INT-RP-206-FR18.

—By Delpha Noble
Intermountain Station



The process of fuel appraisal.

Trees help keep a forest fertile

A scientist may travel a short distance to his field plot in the canopy of an old-growth Douglas-fir, but he climbs straight up.

Scientists gathering information from study plots as varied as the canopies of old-growth trees and the gravels of mountains streams on the Nation's first Experimental Ecological Reserve—the H. J. Andrews Experimental Forest in Oregon—are learning more about the way forest ecosystems function. Their findings will help forest managers make decisions that affect the long-term productivity of western forests.

"What we're doing here," says Ecologist Jerry Franklin of the Pacific Northwest Forest and Range Experiment Station, "is learning how forest ecosystems are put together and how the interrelationships between organisms are affected by variations in environment and by natural and human disturbances." Franklin is in charge of the Andrews Experimental Forest, where scientists from the Pacific Northwest Station, Oregon State University, and the University of Oregon are conducting long-term studies, and other scientists come to do short-term studies.

Franklin is one of the scientists who saw the need for a more intensive look at basic ecological processes after early studies produced valuable information on silvicultural, logging, and road-building methods.

"Information from our research is particularly valuable to forest managers," says Franklin, "because it comes from scientists of several biological and physical disciplines, all looking at different aspects of forest functions on a research site that is representative of the Douglas-fir and hemlock forests on the west slope of the Cascade Range." Scientists are aided in their work by almost 30 years of data collected since the Experimental Forest was established in 1948. They also share data with each other and exchange ideas and points of view.

"The whole point of multi-disciplinary research is to learn how to maintain the productivity of the forest while obtaining goods and services from it," says Franklin. "Forest managers are often under pressure to emphasize products, and they need information to help them account for the long-term impacts. We scientists need to provide them with information to forecast the effects of their management on ecological processes that may take decades or centuries—changes they will not be around to see."

Arthur McKee, botanist and resident manager at the Experimental Forest, agrees on the value of the research to forest managers. "Because we're looking at all the basic forest processes, we're producing information that is definitely in tune with multiple-use management," he says. "As we learn to model these processes we help managers get a clearer picture of the options for influencing the rate and timing of some natural processes and predict the results of their management activities."

As timber harvest moves to steeper slopes at higher elevations, it becomes more important to understand how a forest functions. "Productivity depends on processes that provide nutrients and stability to the soil mantle and to streams," says Franklin. "We're finding new information about the importance of trees in these processes. Alive and dead, standing and down, trees play a series of roles in slowing the movement of nutrients out of the forest and producing and recycling nutrients."

The functions

The functions of trees in the forest ecosystem, now better understood through research at the Experimental Forest, include the following:

1. Logs, root wads, and other large woody debris, which fall or slide into small mountain streams, reduce stream velocity. This debris gradually causes pools and short waterfalls to form. Floating vegetation collects in the pools where invertebrates like beetles, snails, and caddis flies gouge, scrape, and shred needles, twigs, and other organic material. They utilize some of the nutrients and pass them on for reuse by aquatic plants and other invertebrates. The pools also provide places for sediment to settle and gravel beds to form, improving habitat for fish. Large logs cast dark shadows where fish can hide or feed on invertebrates. A log may fill these roles for more than 100 years. During that time, it is gradually broken down by mechanical forces and decomposed to reusable nutrients.

2. Logs on the forest floor contribute nutrients to soil and water through the action of decay fungi, insects, and bacteria. Logs provide habitat and nutrients for tree seedlings. They also provide habitat for birds, amphibians, and small mammals, all of which play important roles. Many small mammals, for example, dig up and eat truffles—fungi that grow underground. The undigested spores of the truffles are distributed as the animals travel from established forest to cut-over areas, providing new sources of the mycorrhizal fungi essential to most plants. Logs are also runways for small animals, and they help stabilize slopes and retard soil erosion.

3. Some trees stand for many years as snags. During this time microscopic organisms decompose wood tissue, release nutrients, and fix nitrogen. The larger snags provide perches for birds and homesites for cavity-nesting birds and small mammals, which eat insects that damage live trees.

4. Some trees are habitat for vegetation that contributes new sources of nitrogen to the forest. One of these is the lettuce-like lichen, *Lobaria oregana*. Scientists have found that this lichen is one reason old-growth Douglas-fir trees grow well even after 400 years. The lichen lives in the upper half of tree canopies, often more than 200 feet above the ground. It takes nitrogen from the air for its own growth, and when it falls to the ground, dies, and decomposes, the nutrients are leached into the soil and become available to the old-growth trees and other vegetation. This lichen is one of many organisms that find optimum habitat in the crowns of old-growth trees.

5. Still other trees and shrubs, like red alder and ceanothus, convert nitrogen from the atmosphere to usable nutrients. Scientists are now wondering whether, in the long run, utilizing the ability of these species to replenish the soil under new conifer forests may not be more effective and less costly than using artificial fertilizers.

6. Trees slow down the movement of nutrients from the forest by slowing erosion. They hold soil on hillsides through the anchoring action of their roots. They also reduce the erosive impact of falling raindrops by reducing the amount of water which reaches the soil and by providing a layer of dead needles and twigs on the forest floor which cushions the impact on the soil surface. Plants also take water from the soil and transpire it to the air. The hydrologic impact of these stabilizing functions is especially important if slopes are steep, soils are unstable, ground water levels are high, and it rains a lot—as it does in the Pacific Northwest in fall and winter.

Stream gages monitor hydrologic processes.

New indications of the importance of trees in slowing erosion have come from records kept on the Experimental Forest since the early 1950's. These indicate that clear-cuts have generated nearly as much landslide erosion as roads. Roads cause more landslide erosion from the area they affect than clearcuts do. But clear-cut slopes occur over a much wider area. Geologist Fred Swanson of Oregon State University, who is studying earth movements on the Experimental Forest, says there may be a switch in importance from roads to clearcuts: "Roads have been blamed in the past, and many problems have been corrected. Meanwhile logging is getting into more unstable ground. In parts of the Coast Range over the last ten years, the frequency of slides in clearcuts has gone up, while the frequency of slides from roads has declined. More than 75 percent of the slides which occurred during big storms in 1975 and 1977 were in clearcuts."

7. Trees—or the absence of them—are the key element in a sequence of events that is responsible for

Botanist Bill Denison and Soil Scientist Dick Fredriksen hold an impromptu conference after meeting unexpectedly on the Andrews.

On unvegetated slopes, dry ravel can be an important agent of erosion.

some of the most destructive storms on the west slope of the Cascade Range. It begins after snow has accumulated during a cold spell. Then, as temperatures rise and rain begins, the heat carried to the snowpack by rainwater and condensation of water vapor from the warm, moist air mass on the snow's surface causes rapid melting. Snowmelt water and condensate then combine with rain to produce major runoff. The phenomenon is called "rain-on-snow runoff" according to Hydrologist Dennis Harr of the Pacific Northwest Station. "Only part of the snowmelt is caused by rain itself. At the Andrews, this combination of snowmelt and rain has caused major runoff five times as often as rain alone. We think snowmelt is greater on unforested slopes because the movement of warm, moist air over the snow surface is greater and supplies heat to the snow faster than in forested areas."

Rain-on-snow runoff is most likely on southwest-facing steep slopes because of their orientation to prevailing winter winds. Most landslides on the Experimental Forest have occurred during periods of rapid snowmelt.

The importance of trees in slowing erosion is illustrated dramatically by their absence during rain-on-snow runoff. It is this type of event that accounts for the greatest, swiftest, and most violent loss of soil and nutrients by erosion. Soil Scientist Dick Fredriksen of the Pacific Northwest Station has studied such storm runoff extensively, using data from stream gages that have been recording runoff since 1952. Fredriksen had personal experience with storms when he was resident manager of the Experimental Forest from 1960 to 1965. "You can't believe what happens," he says, "small headwater streams that are only a trickle in summer become raging torrents. Unstable ground that becomes saturated with water slides into streams, carrying debris with it. A tumbling, churning mass of mud, rocks, and logs may go hurtling downstream, gouging stream banks and scouring the stream channel to bedrock. As the moving debris gathers momentum, massive jams of logs slam against road fills and plug culverts too small to let the debris pass. Then streams flow over roads and wash out road fills."

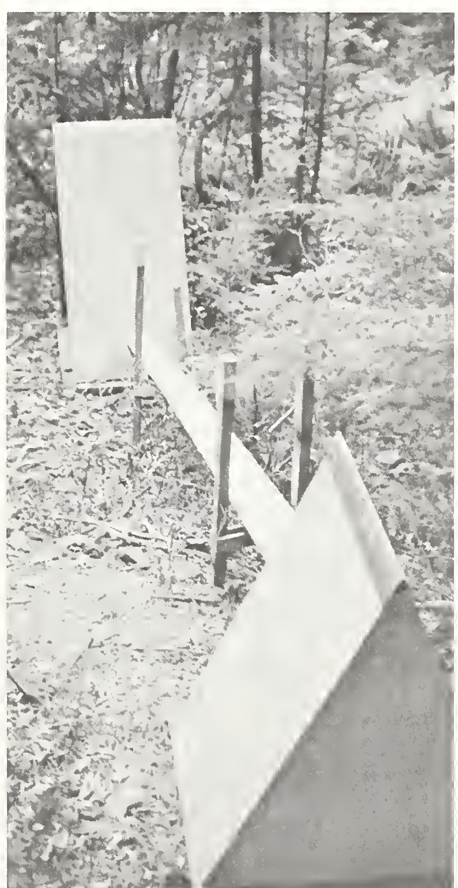
The studies of Fredriksen and others formed the basis for guidelines for building roads, stream crossings, and drainage structures to accommodate the accelerated runoff of severe storms. The scientists also recommended that forest managers send crews out during storms to check conditions and make emergency repairs. Several of the forests in the Pacific Northwest Region of the Forest Service began doing this several years ago. They call the practice FERM (for Flood Emergency Road Maintenance). It has probably saved thousands of dollars in road damage for each major storm, Fredriksen believes.

"Managers can learn a lot if they go out after a big storm," says Swanson. "It is easier then to identify problem areas." On the Mapleton District of the Siuslaw National Forest, which has a good deal of unstable land, the damage from more than 300 slides during a storm in 1975 convinced the staff of the value of a continuing inventory of landslides. "This inventory has been very helpful in identifying unstable slopes which require special management," says Swanson. He points out that an inventory also provides a basis for comparing the cost of slide prevention measures with the benefits of reduced erosion and stream impacts, and lower road repair costs.

Managers are involved

Forest managers and scientists working on the Experimental Forest exchange information in a number of ways. "A dialog between scientists and managers is essential to setting realistic goals and priorities for the rate and directions of research," McKee says. Scientists offer training courses and workshops for managers where they report preliminary findings from research before data collection is complete and papers written. They also answer questions from managers and find out what their problems are. Informal discussions are held on field trips. Individual requests for field trips or help with problems or interpretations of data are an everyday task of the scientists.

A slow-moving earth slide has split a cedar tree. Progress of the slide is being measured by a crack meter and related to factors such as rainfall.



Inquiries about the research program should be directed to Jerry Franklin, Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, Oregon 97331 (telephone 503/757-4362 or FTS 420-4362). Scientists who would like information about the Experimental Forest as a research facility can write to Franklin or Arthur McKee, Manager, H. J. Andrews Experimental Ecological Reserve, P. O. Box 300, Blue River, Oregon 97413.

Since 1969 the Experimental Forest has been an intensive study site for the Coniferous Biome of the International Biological Program. It was the high quality of the multi-disciplinary research under this program that led the National Science Foundation to support the Andrews as the first Experimental Ecological Reserve in 1977.

The Experimental Forest is also one of 28 sites that form the U.S. portion of an international system of Biosphere Reserves established under the Man in the Biosphere Program of the United Nations Education, Scientific and Cultural Organization.

Research done on the Experimental Forest is cited in more than 350 scientific papers. A list of these is available from Franklin.

—by Dorothy Bergstrom
Pacific Northwest Station

Publications

Computer programs aid fire planning

New computer programs for evaluating fire lookout sites and for computing the amount of time it takes firefighters and equipment to reach a fire are described in reports from the Pacific Southwest Station's Forest Fire Laboratory. Romain M. Mees, operations research analyst at the Laboratory, has developed the program "HIST" for estimating the distribution of fires that have occurred in the past in relation to their distance from existing or proposed lookout sites. The program can be used to determine the number of fires that were visible from the lookout as well as those that were below the lookout's line of sight. Mees' "SEEN" program can be used to produce a map overlay of the areas that can be seen within a 12- to 15-mile radius of a lookout. Both programs are described in the paper, "Seen Areas and the Distribution of Fires About a Lookout," (General Technical Report PSW-26-FR18).

In his second report, Mees describes a computer program that can be used to compute how long it will take initial attack resources to reach a fire. Dispatchers using the program need to have 24-hour access to a low-speed interactive terminal and need to prepare—for permanent storage at a computer—data on their unit's road network and on all their available firefighting resources. Then, as soon as possible after a fire breaks out, the dispatcher can dial the computer, give the location of the fire, and get a printout of all initial attack resources with arrival times that are within the specified maximum. The resources are listed in order of arrival times, beginning with those that will be the first to arrive. The computer calculations take into account getaway time, actual travel time on the road or in the air, and the off-road travel time. Dispatchers and fire planners can also use the program any time during the year to calculate standard dispatches for areas on their unit. More information about the program is in General Technical Report PSW-27-FR18, "Computing Arrival Times of Firefighting Resources for Initial Attack." The Pacific Southwest Station has copies of both papers.

"Mystic Mountain" gives players practice in land-use planning

"Mystic Mountain" is a new land-use planning game that challenges players to come up with a series of land-use plans that will meet continually changing national needs for timber, recreation, and other forest resources. The game condenses 75 years of the future of the hypothetical "Mystic Mountain National Forest" into 4 hours of playing time.

The "Mystic Mountain" game gives players an understanding of the problems and rewards of wildland planning.

In the first part of the game, teams of two or three people determine what portions of Mystic Mountain should be developed, logged, or preserved over the next 15 years. In the four playing periods that follow—each representing 15 years—they make further decisions about what to do with the land. As they move from one planning period to the next, players may be faced with a new "scenario" of national conditions.

"The game stresses that the future is uncertain," says one of its developers, researcher Edward C. Thor of the Pacific Southwest Station's Land-use Planning Unit in Berkeley, California. Players who plan for an uncertain future, preserve enough options to meet changing demands, and realize that some activities in some locations cut off more options than others, will be winners in the "Mystic Mountain" game and will probably be winners in real-life land-use planning as well. Details on the game, along with a game map, set of rules, and instructions for the leader, are in the publication, "Mystic Mountain: an educational alternative futures wildland planning game," by Edward C. Thor and James L. Creighton (General Technical Report PSW-30-FR18). Copies are available from the Pacific Southwest Station.

Ponderosa pine publications issued

Growth of ponderosa pine in California plantations, and important variations in the moisture content of ponderosa pine litter, are described in two publications issued recently by the Pacific Southwest Station. Research Foresters William W. Oliver and Robert F. Powers present estimated yields for plantations of ponderosa pine in their report, "Growth Models for Ponderosa Pine: I. Yield of Unthinned Plantations in Northern California" (Research Paper PSW-133-FR18). The tables can be used for plantations in northeastern and northcentral California. They will be most accurate for unthinned stands where survival of seedlings has been good, spacing is regular, canopies are closed, competition from brush species is minimal, and mortality from insects, diseases, storms, or other factors has been low.

According to the authors, the tables were needed because growth and yield information in the past has been "inadequate for plantations on highly productive sites." This lack of reliable data has "hindered such management decisions as choosing initial spacing, determining when to thin, and deciding when and how to control competing brush species."

The tables show diameter, basal area, and net cubic volume yields at site indices from 40 through 120 feet at 50 years of age. The tables can be used for estimating future productivity of stands ranging in age from 10 to 50 years and in spacings of from 6 by 6, to 12 by 12 feet. For each site index, the tables show yields at 5-year intervals and for 6, 8, 10, and 12-foot spacings. The mathematical model used to arrive at the figures is described in the report, as are some of the major trends in ponderosa growth that are suggested by the tables.

The report is the first in a series of three articles on growth models for ponderosa pine; the future parts of the series will discuss the maximum growth potential of ponderosa pine and stem and crown growth of individual trees in plantations. Copies of the first report are available from the Pacific Southwest Station.

In the paper, "Radiation Effects on Moisture Variation in Ponderosa Pine Litter," Researcher Clive M. Countryman reports that major differences in the moisture content of litter can occur on nearby areas of a ponderosa pine forest floor. According to Countryman, these differences can be significant enough to affect the ignition and spread of fire, so must be considered in fire-danger rating, firefighting, and in preparing for a prescribed burn. He points out that the amount and the intensity of solar radiation reaching the forest floor through openings in the crown canopy, and the effect openings have in cooling the litter at night, are key factors in explaining the site-to-site variations. "Data collected indicate that litter even briefly exposed to direct sunlight can become substantially lower in moisture than areas not exposed," he says. "The lower moisture level will persist even after the litter is again shaded." He concludes that the effects of canopy openings should be evaluated, along with such standard factors as latitude, time of day and year, stand characteristics, atmospheric conditions, and topographic configurations, in determining litter moisture. Details are in Research Paper PSW-126-FR18, available from the PSW Station.

Riparian symposium proceedings

A national symposium titled "Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems," was held in Callaway Gardens, Georgia on December 11-13, 1978.

The gathering, sponsored by a multitude of government agencies and private organizations, focused on the ecological importance of riparian ecosystems and the need for comprehensive interagency planning and management to protect and maintain these ecologically sensitive systems.

A wide variety of papers presented findings of on-going programs, current positions of various government agencies, new insights into ways of developing comprehensive interagency programs to address riparian ecosystem problems, and characteristics, values, and management of floodplain wetlands and other riparian environments.

Copies of the proceedings are available from the Forest Service—USDA, Office of Information, P.O. Box 2417, Washington, D.C. 20013. Request General Technical Report WO-12.

Cattle vs. ponderosa pine

A recent study on the Manitou Experimental Forest in central Colorado researched the effect of cattle grazing on ponderosa pine regeneration on pine-bunchgrass ranges.

Results show that protection of natural and artificial pine regeneration from cattle grazing is not necessary, provided the grazing intensity is prescribed to use 40 percent or less of the principal bunchgrasses; forested ranges are in fair to good condition; and natural watering places or supplemental water is available to assure an adequate water supply for livestock.

Findings also stress the importance of proper nursery and planting procedures to assure a good stand of new trees.

Study results are discussed in "Effects of Cattle Grazing on Ponderosa Pine Regeneration in Central Colorado," by Pat O. Currie, Carleton B. Edminster, and F. William Knott.

For your copy write the Rocky Mountain Station and request Research Paper RM-201-FR18.

Red alder and western juniper get attention

Two western tree species were the subject of meetings in early 1977 to summarize current knowledge about them and identify research needs. Although they grow in very different environments, red alder and western juniper have several things in common. Both are held in low esteem by most forest and range managers, who consider them weeds to be eliminated in favor of more valued vegetation. Neither species is being intentionally managed for its potential benefits, but attitudes toward both have become somewhat more positive in recent years.

Red alder is a fast-growing hardwood which currently makes up 15 percent of the commercial forests of western Oregon and Washington. It provides material for furniture, lumber, plywood and other wood products, but the industry does not have steady markets or reliable sources of raw material. Because of its rapid early growth, alder may become increasingly attractive as a source of wood fiber, and perhaps energy supplies, in times of timber and fuel shortages.

Red alder also has another important attribute. It absorbs nitrogen from the air and converts it to forms which can be used by other vegetation. This capability makes it an attractive alternative to chemical fertilizers as costs for these increase and future supplies are less certain. Recent research suggests that alder may also help reduce the root rot problems of conifers.

Western juniper occurs in the transition zone between open plains and pine timber, principally in central and eastern Oregon but also in California, Nevada, Washington, and Idaho. During the past 100 years the species has increased at a phenomenal rate throughout its range, perhaps because of the absence of wildfire. The tree is formidably hard to control once it is old enough to form a closed stand.

The spread of juniper has alarmed many land managers because it competes with forage plants for water, apparently using deep soil moisture even in winter when other plants are dormant, and its spread is reducing the amount of forage available for livestock and mule deer. Juniper habitat, however, provides essential thermal and hiding cover for mule deer, coyotes, and a variety of wildlife. In fact, this habitat supports greater populations and more species of wildlife than ponderosa pine, lodgepole pine, or big sage brush habitats. Participants in the juniper meeting agreed that research is badly needed to determine the cause of juniper spread and to provide a basis for decisions about manipulating the balance of forage and cover.

The papers presented at both meetings have been published and are now available from the Pacific Northwest Station. They are "Utilization and Management of Alder" (General Technical Report PNW-70), which includes 37 papers, and "Proceedings of the Western Juniper Ecology and Management Workshop" (General Technical Report PNW-74), which includes 12 papers.

☆GPO 679-133/383

Fertilizer as a thinning tool

Can forest fertilization be used to thin overstocked stands of Douglas-fir and western hemlock on sites of low productivity? Answers to that and related questions were explored in a recent study by soil scientist Dick Miller of the Pacific Northwest Station's Silviculture Laboratory at Olympia, Washington.

Miller looked at the results of fertilizer trials in both pure and mixed stands of Douglas-fir and western hemlock to see if he could find evidence of a "thinning" effect. Results of his findings are available in a paper presented at the Western Hemlock Management Conference in Washington in May 1976.

Miller concluded that the main potential benefit from fertilization is increased stand growth. Since fertilizer also accelerates competition between trees, some trees grow faster while others are suppressed. Upper crown classes in unthinned stands generally respond more to fertilization than lower crown classes. The differential response may speed up mortality in lower crown classes and contribute to a thinning effect.

The increase in mortality of non-crop trees varies with the amount of fertilizer applied. Moderate to heavy doses of nitrogen, for example, can increase winter damage and mortality in Douglas-fir. With light to moderate doses of nitrogen, reductions in overstocking will be much slower than with chain saw. For efficient production of saw timber, mechanical thinning, preferably done early and combined with fertilizing, or stand replacement should be considered.

Miller points out that the full story is not yet known at several study areas. He suggests that measurements over a decade or more are needed to assess the long-term benefits of fertilizing as a thinning tool and possible alternative to precommercial thinning.

For details see "Effects of Fertilization on Mortality in Western Hemlock and Douglas-fir Stands" by Richard E. Miller, in Proceedings of Western Hemlock Management Conference, 1976. Copies are available from the Pacific Northwest Station.

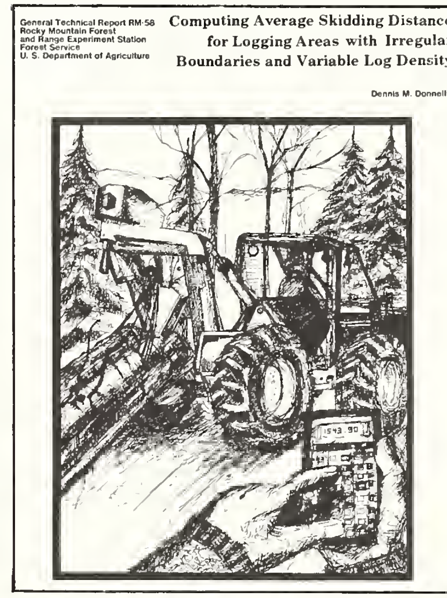
Computing skidding distances

A new report out of the Rocky Mountain Station describes a method using a hand-held calculator to figure average skid distance for an irregular area with or without variable log density.

Methods currently available for computing average skid distance assume that logs are evenly distributed over the area. While this assumption may have been satisfactory in the past, current timber harvest practices can cause different log densities on subareas of the same skid area. Average skid distance can be significantly different if variable log density is considered by subarea.

The methods described in the paper "Computing Average Skidding Distance for Logging Areas with Irregular Boundaries and Variable Log Density," by Dennis M. Donnelly, apply either to tractor skidding or to cable yarding distances.

If you would like details, write the Rocky Mountain Station and ask for General Technical Report RM-58-FR18.



Don't miss the July issue. We'll tell you about scientists who are gaining a new appreciation for red alder; look at a research effort to find better ways to utilize wood in the Rockies; we'll give you an update on the SEAM (Surface Environment and Mining) Program; and provide other items of interest.

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